PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B22D 27/00, C22C 1/08 B22D 25/06, 19/00, 21/04	A1	(11) International Publication Number: WO 94/09931 (43) International Publication Date: 11 May 1994 (11.05.94)

(21) International Application Number: PCT/CA93/00471

(22) International Filing Date: 4 November 1993 (04.11.93)

(30) Priority data:
971,307 4 November 1992 (04.11.92) US

(71) Applicant: ALCAN INTERNATIONAL LIMITED [CA/CA]; 1188 Sherbrooke Street, West, Montreal, Quebec H3A 3G2 (CA).

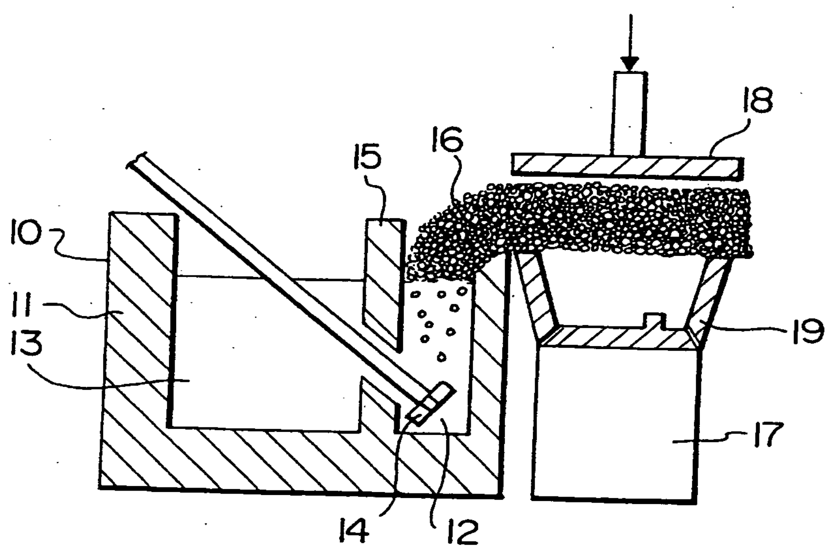
(72) Inventors: KENNY, Lorne, Douglas ; R.R. #2, Inverary, Ontario K0H 1X0 (CA). THOMAS, Martin ; 367 College Street, Kingston, Ontario K0H 1X0 (CA).

(74) Agents: EADES, Norris, M. et al.; Kirby, Eades, Gale, Baker, P.O. Box 3432, Station D, Ottawa, Ontario K1P 6N9 (CA).

(81) Designated States: AU, CA, JP, KR, NO, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: PROCESS AND APPARATUS FOR SHAPE CASTING OF PARTICLE STABILIZED METAL FOAM



(57) Abstract

Shaped articles are produced from foam metal by a procedure wherein the foam is formed by heating a composite of a metal matrix and finely divided solid stabilizer particles above the solidus temperature of the metal matrix and discharging gas bubbles into the molten metal composite below the surface thereof to thereby form a stabilized liquid foam on the surface of the molten metal composite. According to the novel feature the stabilized metal foam in liquid form is shape cast by being pressed into a mould and permitted to cool and solidify. The density of the cast part is essentially unchanged from that of the starting liquid foam.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

Process and Apparatus for Shape Casting of Particle Stabilized Metal Foam

Technical Field

This invention relates to a process and apparatus for shape casting particle stabilized metal foam, particularly particle stabilized aluminum foam.

Background Art

Lightweight metal foams have high strength-to-weight ratios and are extremely useful as load-bearing materials and as thermal insulators. Metal foams are characterized by high impact energy absorption capacity, low thermal conductivity, good electrical conductivity and high absorptive acoustic properties.

A particle stabilized metal foam of exceptional stability is described in Jin et al U.S. Patent 4,973,358, issued November 27, 1990. According to that patent, a composite of a metal matrix and finely divided solid stabilizer particles is heated above the liquidus temperature of the metal matrix. Gas is then introduced into the molten metal composite below the surface of the composite to form bubbles therein. These bubbles float to the top surface of the composite to produce on the surface a closed cell foam. The foam which forms on the surface of the molten metal composite is a highly stable liquid foam, i.e. the foam cells do not collapse under their own weight. This stable liquid foam is then cooled below the liquidus temperature of the melt to form a metal foam product having a plurality of closed cells and the stabilizer particles dispersed within the metal matrix.

A method for shaping metal foam is described in Niebylski et al, U.S. Patent 3,873,392, issued March 25, 1975, in which solid metal foam is compressed such that cell walls are crushed. Although heat may be used, it is preferred that the temperature does not exceed about 38°C below the melting point of the base metal.

Another method for shaping a metal foam body is described in Erb, U.S. Patent 3,595,059, issued July 27, 1971. In this method, the forming device is reciprocated causing localized heating and crushing of the walls of the foam structure.

Shape casting of molten metals, such as aluminum, can be carried out in a wide variety of closed moulds. One such technique is squeeze casting, also known as liquid-metal forging, in which molten metal solidifies under pressure within closed dies positioned between the plates of a hydraulic press. The applied pressure and the instant contact of the molten metal with the die surface produces a rapid heat transfer condition that yields a pore-free fine-grain casting with mechanical properties approaching those of a wrought product. Semi-solid metal working is also used, which incorporates elements of both casting and forging. This may be referred to as rheo-casting, thixocasting or stir casting. In this procedure a thixotropic material is formed which can be moved and handled.

It is the object of the present invention to provide a shape casting technique for particle stabilized metal foam which takes advantage of the unique characteristics of the particle stabilized metal foam.

<u>Disclosure of the Invention</u>

In the present invention, a composite of a metal matrix, e.g. aluminum alloy, and finely divided solid stabilizer particles is heated above the solidus temperature of the metal matrix. Gas is then introduced into the molten metal composite below the surface of the composite to form bubbles therein and these bubbles float to the surface of the composite to produce on the surface a closed cell metal foam. The metal foam which forms on the surface of the molten metal composite is stabilized by the presence of the particles and this stabilized liquid foam has considerable structural integrity.

In one embodiment of this invention, the stabilized liquid foam is continuously drawn off from the surface of the molten metal composite and is thereafter cast into a shaped, solidified metal foam article. The shape casting is done while the foam is in the liquid form either immediately after foam generation or by reheating a previously cast slab of liquid foam to temperatures above the solidus temperature.

The shape casting can be done by a variety of techniques, such as squeeze casting, etc. Since the foam is in the liquid or liquid+solid state, the pressure required to deform the foam is low. Cells do not collapse under pressure since within the mould the cells are under a state of hydrostatic stress. Thus, density of the formed part is essentially unchanged from that of the starting foam material. The formed article exhibits a continuous skin due to the metal flow during the shaping operation.

The term "shape casting" as used in the present invention means that the liquid foam is pressed into a mould sufficient only to cause the liquid foam to assume the shape of the mould without compressing and/or collapsing the cells of the foam. Although, the pressing into the mould must be done carefully to avoid compressing and/or collapsing the cells, it surprisingly can be carried out at high rates without any problems. It is also possible to subject the foam to "shape forming" in which the foam within the mould is subjected to further deformation. This shape forming can be done when the metal foam is in the liquid or liquid/solid state and it can be done with or without densification of the foam. For instance, foam outside the mould proper, e.g. a flange, may be compressed resulting in densification of the foam in that area. It is also possible to press a shape forming tool into the foam in a mould to further modify the shape of the article being cast without densifying it. An important advantage of the processes of

the present invention is that parts can be made to net or near net shapes, thereby avoiding machining.

The success of the forming method is highly dependent upon the nature and amount of the finely divided solid refractory stabilizer particles. A variety of such refractory materials may be used which are particulate and which are capable of being incorporated in and distributed through the metal matrix and which at least substantially maintain their integrity as incorporated rather than losing their form or identity by dissolution in or chemical combination with the metal.

Examples of suitable solid stabilizer materials include alumina, titanium diboride, zirconia, silicon carbide, silicon nitride, magnesium oxide, etc. The volume fraction of particles in the foam is typically less than 25% and is preferably in the range of about 5 to 15%. The particle sizes can range quite widely, e.g. from about 0.1 to 100 μm, but generally particle sizes will be in the range of about 0.5 to 25 μm with a particle size range of about 1 to 20 μm being preferred.

The particles are preferably substantially equiaxial. Thus, they preferably have an aspect ratio (ratio of maximum length to maximum cross-sectional dimension) of no more than 2:1. There is also a relationship between particle sizes and the volume fraction that can be used, with the preferred volume fraction increasing with increasing particle sizes. If the particle sizes are too small, mixing becomes very difficult, while if the particles are too large, particle settling becomes a significant problem. If the volume fraction of particles is too low, the foam stability is then too weak and if the particle volume fraction is too high, the viscosity becomes too high.

The metal matrix may consist of any metal which is capable of being foamed. Examples of these include aluminum, steel, zinc, lead, nickel, magnesium, copper and alloys thereof.

The foam-forming gas may be selected from the group consisting of air, carbon dioxide, oxygen, water, inert gases, etc. Because of its ready availability, air is usually preferred. The gas can be injected into the molten metal composite by a variety of means which provide sufficient gas discharge pressure, flow and distribution to cause the formation of a foam on the surface of the molten composite. Preferably, a strong shearing action is imparted to a stream of gas entering the molten composite, thereby breaking up the injected gas stream into a series of bubbles. This can be done in a number of ways, including injecting the gas through a rotating impeller, or through a vibrating or reciprocating nozzle. It is also possible to inject the gas within an ultrasonic horn submerged in the molten composite, with the vibrating action of the ultrasonic horn breaking up the injected gas stream into a series of bubbles. The cell size of the foam can be controlled by adjusting the gas flow rate, as well as the impeller design and rotational speed where used or the amplitude and frequency of oscillation or vibration where an oscillating or vibrating system is used.

In forming the foam according to this invention, the majority of the stabilizer particles adhere to the gas-liquid interface of the foam. This occurs because the total surface energy of this state is lower than the surface energy of the separate liquid-gas and liquid-solid state. The presence of the particles on the bubbles tends to stabilize the froth formed on the liquid surface. It is believed that this may happen because the drainage of the liquid metal between the bubbles in the froth is restricted by the layer of solids at the liquid-gas interfaces. The result is a liquid metal foam which is not only stable, but also one having uniform pore or cell sizes throughout the foam body since the bubbles tend not to collapse or coalesce.

The pores or cells of the foam may be as large as 50 mm, provided they are uniform in size. However, small uniform cell sizes averaging less than 5 mm are preferred. The small cell sizes have the advantage of easily moving or deforming during shaping to fill the mould. With larger cells, on the other hand, shearing or tearing of the cell walls may occur when complex shapes are made.

In a preferred embodiment of the present invention, a layer of stabilized liquid foam is drawn off a foam generating box and this freshly generated foam layer is pressed by a platen down into a preheated mould. The formed article exhibits a continuous outer skin due to metal flow during the shaping operation.

In another preferred embodiment, a previously cast slab of stabilized metal foam is heated to temperatures above the solidus and this reheated slab is again pressed down into a preheated mould by means of a platen to form a shaped article with a continuous outer skin. This provides a more rigid area for attachment of the shaped part to other structures.

In another preferred embodiment of the invention, it is possible to draw the freshly formed stabilized metal foam away from the foam generating box on a conveyor belt, e.g. a steel belt, and an inverted mould is pressed downwardly from above into the foam travelling on the belt. This is capable of forming a shaped article in the same manner as the previously described platen pressing the foam downwardly into a mould.

In other embodiments utilizing a continuous belt, a series of individual moulds may be mounted on a conveyor belt and these individual moulds pick up stabilized foam emerging from a foam generating box, with the foam being pressed into the travelling moulds by means of platens. Alternatively, a continuous profiled slab of foam may be formed while travelling on a conveyor belt by means of profiled rolls engaging the slab.

Brief Description of the Drawings

In the drawings which illustrate the present invention:

Figure 1 is a sectional view of a metal foam generating box and mould for forming shaped parts;

Figure 2 is a sectional view of the mould of Figure 1 with the part formed;

Figure 3 is a sectional view of a mould for moulding precast and reheated foam;

Figure 4 is a sectional view of the mould of Figure 3 with the part formed;

Figure 5 is a sectional view of a mould forming a bowl-shaped part in a first stage;

Figure 6 is a sectional view of the mould of Figure 5 in a second stage;

Figure 7 is a sectional view showing a system for moulding a part from foam travelling on a conveyor belt;

Figure 8 is a sectional view of the system of Figure 7 with the part formed;

Figure 9 is a diagrammatic sectional view of a foam generating box and conveyor belt;

Figure 10 is a diagrammatic sectional view of a conveyor belt carrying individual moulds;

Figure 11 is a diagrammatic sectional view of a conveyor system for forming a continuous profiled foam strip;

Figure 12 is a photomicrograph of typical metal foam used for the invention;

Figure 13 is a further enlarged photomicrograph showing details of the foam cells;

Figure 14 is a photograph of a bowl-shaped part with a portion cut away; and

Figure 15 is a photograph of a slice through a profiled part, and

Figure 16 (on the sheet with Figures 1 and 2) is a diagrammatic sectional view of a system for forming a curved foam strip.

Best Modes For Carrying Out the Invention

As seen in Figure 1, a metal foam generator 10 comprises a vessel 11 having a divider wall 15 extending between side walls to form a foaming chamber 12 and a holding chamber 13. The holding chamber 13 holds a composite of molten metal matrix and finely divided solid stabilizer particles. Fresh composite is added to chamber 13 as needed. An air injecting impeller 14 with air discharge holes in the impeller extends into the foaming chamber 12 and the mixing action of the impeller with the injection of air therethrough creates foam 16 which rises from the surface of the molten metal composite in the foaming chamber 12. A typical foam is made from Al - 9 Si - 0.8 Mg - 15 SiC composite alloy with small average foam cell size of less than about 5 mm.

Because of the strong and resilient nature of the stabilized liquid foam produced from the composite in the foaming chamber, this foam can be simply drawn off from the surface of the foaming chamber 12.

The freshly formed stabilized liquid foam 16 was drawn above a preheated mould 19 mounted on a support 17. A platen 18 moved downwardly, pushing the foam 16 into the mould 19 to form a shaped article as shown in Figure 2 with a densified flange area 21.

Figures 3 and 4 show an alternative embodiment in which a metal foam block 22 was positioned above mould 19. This preform was preheated to above the liquidus temperature of the metal, i.e. 650°C, before being placed over the mould and the mould was also preheated, to about 300°C. The platen 18 was then moved downwardly, compressing the preform 22 into the mould 19 to form a slotted brick shape 23 as shown in Figure 4. A densified flange area 24 was formed at the periphery of the shaped part. The flange is denser, (consisting of flattened cells) and as such provides a more rigid area for attachment of the shaped part to other structures. For example, holes may be drilled in the flange and bolts or

screws inserted through to an underlying structure.

A bowl-shaped article may be formed using the mould system of Figures 5 and 6. Stabilized liquid foam 27 was placed in the bottom of a graphite bowl-shaped mould 25 and a refractory platen 26 was used to compress and form the exterior surface. The platen 26 was then replaced by a conical shaped platen 29 also formed of graphite which was pressed into the foam to shape form the interior wall of the bowl-shaped final article 30.

Figures 7 and 8 show an arrangement in which stabilized liquid foam 31 was carried on a steel conveyor belt 32. An inverted cylindrical steel mould 33 was pressed downwardly into the foam 31 as shown in Figure 8 to create a shaped foam article 34.

Figure 9 shows the identical foam generator as described in Figure 1, but in this case the foam 16 which was generated was drawn off onto steel conveyor belt 36 which is carried by drive rolls 37. Typical conditions for producing a metal foam with cells of less than about 3 mm are as follows:

Alloy	:	A356+15% SiC
Melt Temp.	:	720°C-630°C
Casting Speed	:	12 cm/minute
Air Flow Rate (nominal)	:	.3 l/minute
Impeller Speed	:	1050 rpm
Slab Dimensions (approx.)	:	5 cm thick x 17 cm wide x 150 cm long

Alternative forms of conveyor belts are shown in Figures 10 and 11, with Figure 10 showing a series of separate moulds 40 mounted in spaced relationship on a conveyor belt 42 travelling on drive rolls 43. As the moulds 40 move past the foam generator 10 they pick up foam as shown and the foam is pressed down into the moulds 40 by means of platen 41 in the same manner as described in Figures 1 and 2.

It is also possible according to the present invention to create a continuous profiled strip of foam and this is described in Figure 11. In this case, a steel belt 42 and drive rolls 43 are again used, but a continuous layer of foam 15 is drawn from the foam generator 10 and this continuous layer 15 of foam is then compressed by means of roll 45 with a profiled shape 46.

It is also possible according to the present invention to create curved strips of foam and this is described in Figure 16. In this case a rotating steel roller 50 is used to pick up the foam 16 starting at a delimiting end stop 51 from the foam generator 10. The foam is pressed down by a rotating shaping roller 53. A shear or similar means 54 is provided to create a second delimiting edge and it is activated when the desired amount of curvature has been cast. The shear may be independent of the rollers as shown in Figure 16 or incorporated as part of the shaping roller itself. The roller 50 may be cylindrical as shown or have non-cylindrical form such as an ellipse or oval. The roller 50 and the shaping roller 53 may also be contoured as in the example of Figure 11 to provide for curved shapes with surfaces that are not flat in form.

The nature of the foam is illustrated by Figures 12 and 13 with Figure 12 being a 4x magnification and Figure 13 being a 100x magnification. Particularly Figure 13 shows the structure of the walls between the cells lined by stabilizing particles. The foam which is used has an average cell size in the range of 2-3 mm.

A metal foam bowl produced by the technique of Figures 5 and 6 is shown in the photograph of Figure 14. This photograph is of a bowl formed of particle stabilized aluminum foam which has been cut to expose the structure. It will be seen that dense layers were formed at the surfaces, but there was no breakdown of the foam structure itself.

The product formed by the system of Figures 1 and 2 is shown in Figure 15. Again, the dense outer surface can be seen and it could also be seen that the interior foam structure remained essentially unchanged.

While preferred embodiments of the present invention have been described in detail for the advantages of the specific details and for purposes of illustration, further modifications, embodiments and variations are contemplated according to the broader aspects of the present invention, all as determined by the spirit and scope of the following claims.

Claims:

1. A process for producing shaped articles of foam metal which comprises providing a stabilized liquid foam metal formed by heating a composite of a metal matrix and finely divided solid stabilizer particles above the solidus temperature of the metal matrix and discharging gas bubbles into the molten metal composite below the surface thereof to thereby form a stabilized liquid foam on the surface of the molten metal composite, shape casting said stabilized liquid foam metal by pressing the stabilized liquid foam into a mould with a pressure sufficient only to cause the liquid foam to assume the shape of the mould without substantial compressing and/or collapsing of the cells of the foam and thereafter cooling and solidifying the foam to obtain a shaped article.

2. A process as claimed in claim 1 wherein the stabilized liquid foam is a freshly generated foam.

3. A process as claimed in claim 1 wherein the stabilized liquid foam is a previously cast stabilized metal foam which has been heated to a temperature above the solidus temperature.

4. A process as claimed in claim 1 wherein the mould is preheated before the stabilized liquid foam is pressed therein.

5. A process as claimed in claim 1 wherein the metal is an aluminum alloy.

6. A process as claimed in any one of claims 1-5 wherein the stabilized liquid foam is pressed into the mould by means of a movable platen.

7. A process as claimed in claim 6 wherein a first movable platen presses the stabilized liquid foam into the mould and forms smooth exterior surfaces on a shaped foam article and a second platen is pressed into the stabilized liquid foam within the mould to form smooth interior surfaces on a shaped foam article.

8. A process as claimed in any one of claims 1-5 wherein the stabilized liquid foam is carried on a moving belt and a vertically reciprocating inverted mould is pressed downwardly into the stabilized liquid foam on the belt to thereby form a shaped foam article.

9. A process as claimed in any one of claims 1-5 wherein a plurality of moulds mounted on a conveyor belt pick up stabilized liquid foam from a foam generator and the foam picked up by each mould is pressed into the mould by means of a reciprocating platen.

10. A process as claimed in any one of claims 1-5 wherein the stabilized liquid foam has cells of uniform size.

11. A process as claimed in claim 10 wherein cells of the stabilized liquid foam have uniform average sizes of less than 5 mm.

12. A process as claimed in claim 1 wherein the shape casting is squeeze casting.

13. A process as claimed in claim 1 wherein the shape casting operation is followed by a shape forming operation.

14. A process as claimed in claim 5 wherein the stabilized liquid foam is carried on a moving roller and a second roller is pressed into the stabilized liquid foam on the first roller to thereby form a curved and shaped foam article.

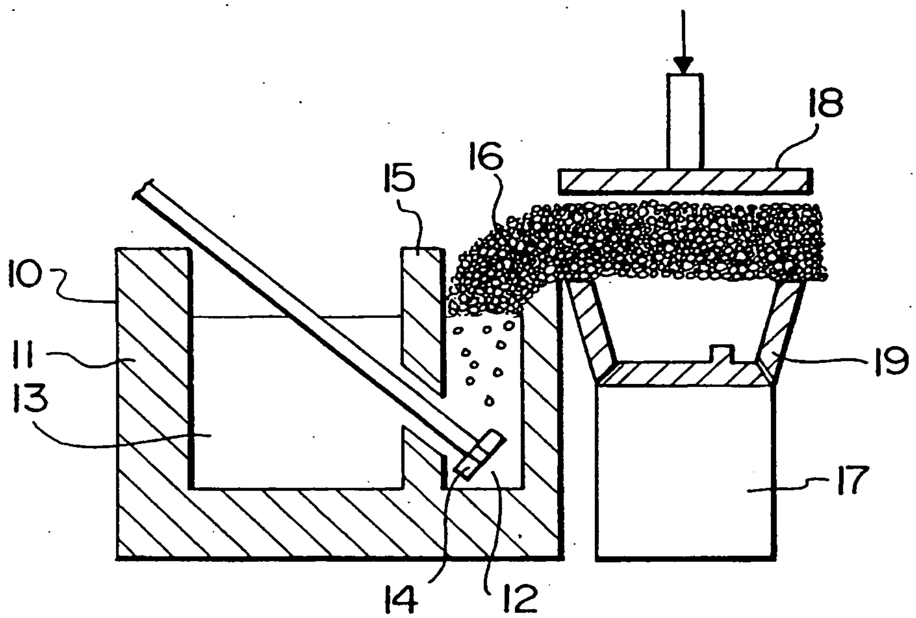


FIG.1

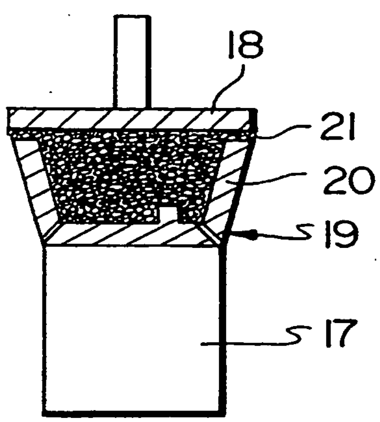


FIG.2

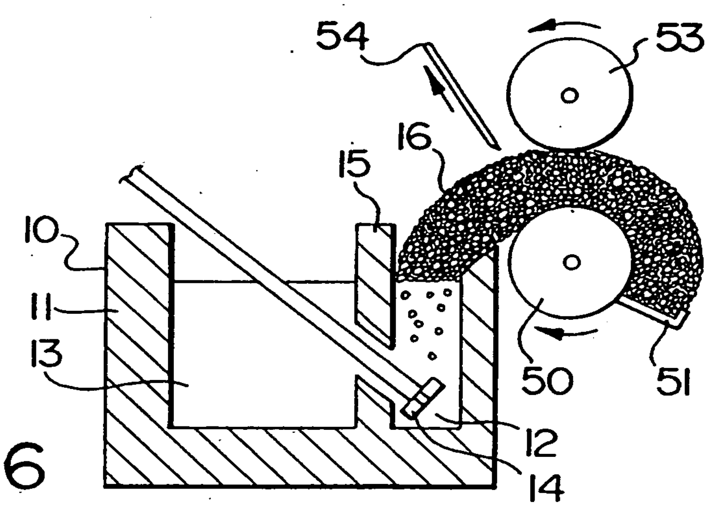


FIG.16

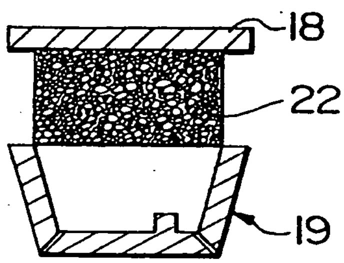


FIG.3

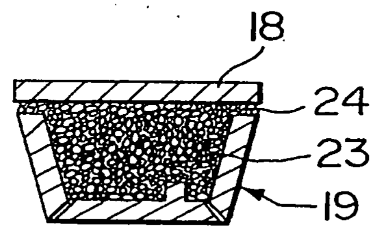


FIG.4

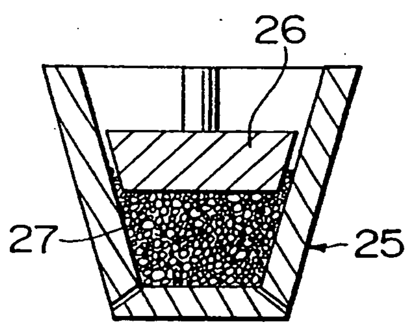


FIG.5

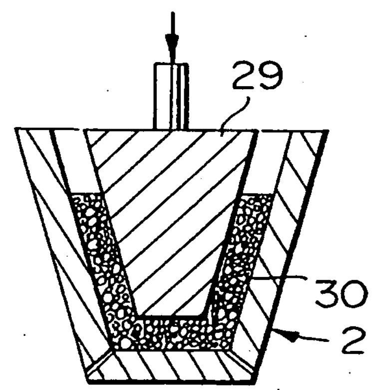


FIG.6

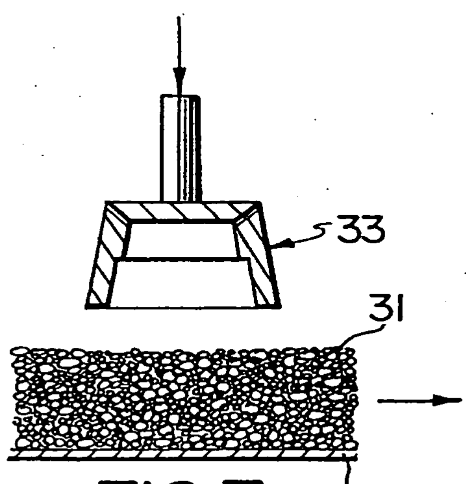


FIG.7

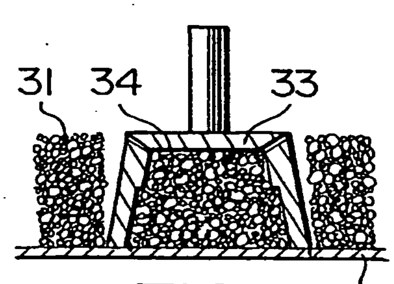


FIG.8

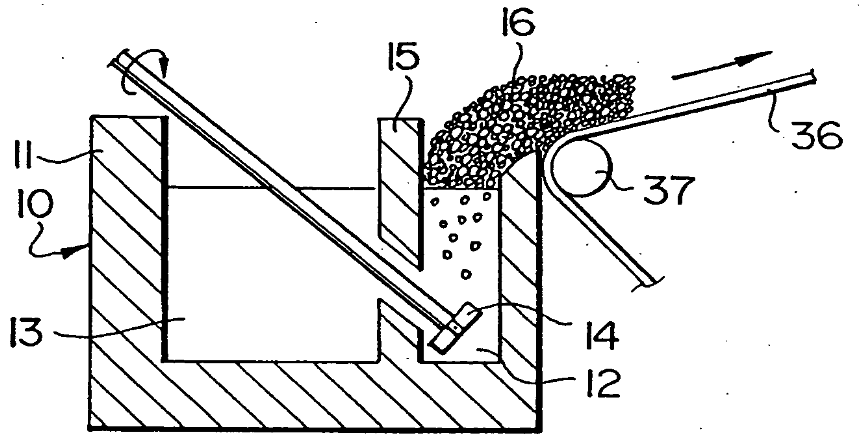


FIG.9

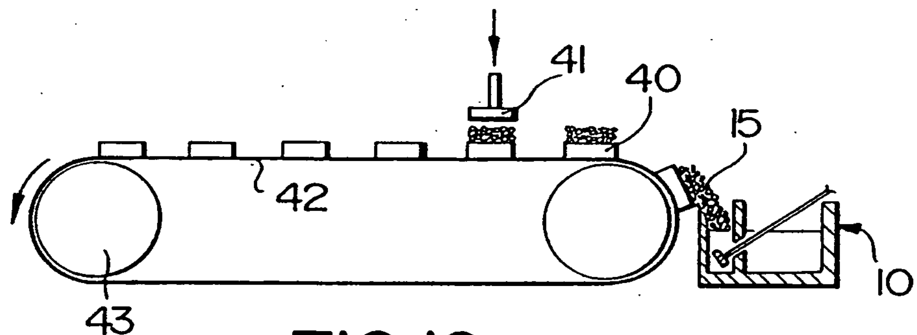


FIG.10

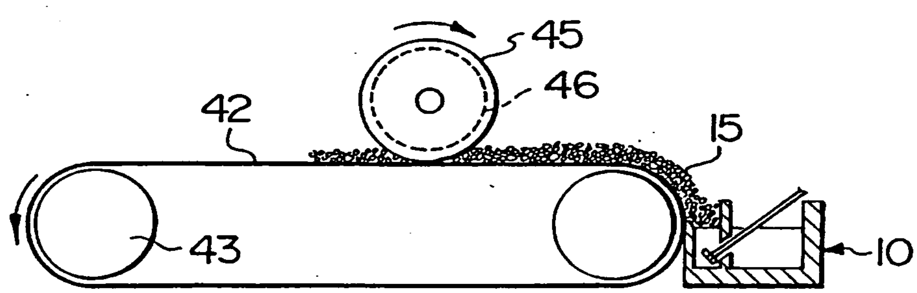


FIG.11

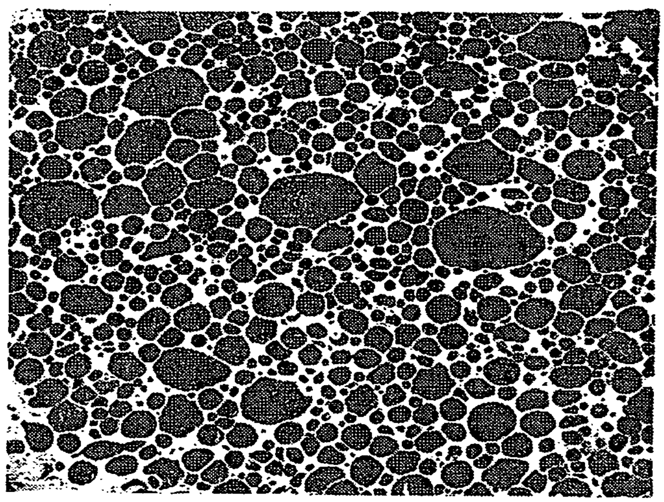


FIG. 12

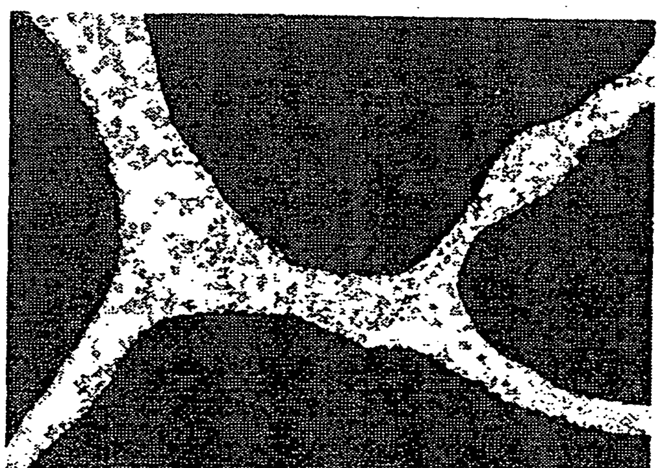
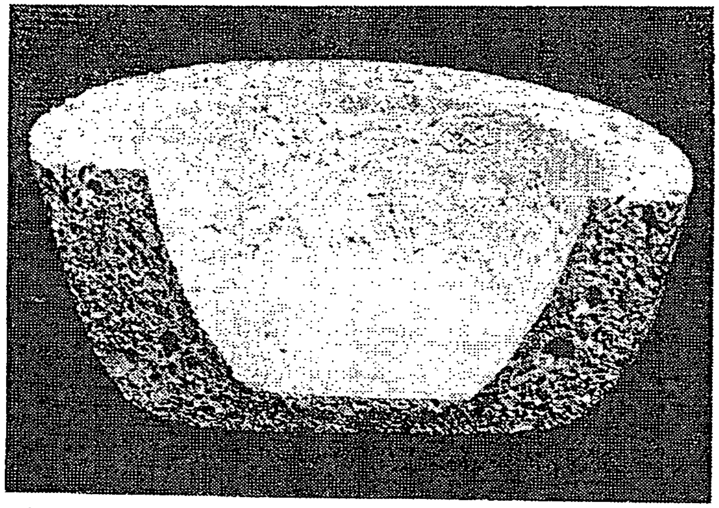


FIG. 13



92-75

IX

FIG.14

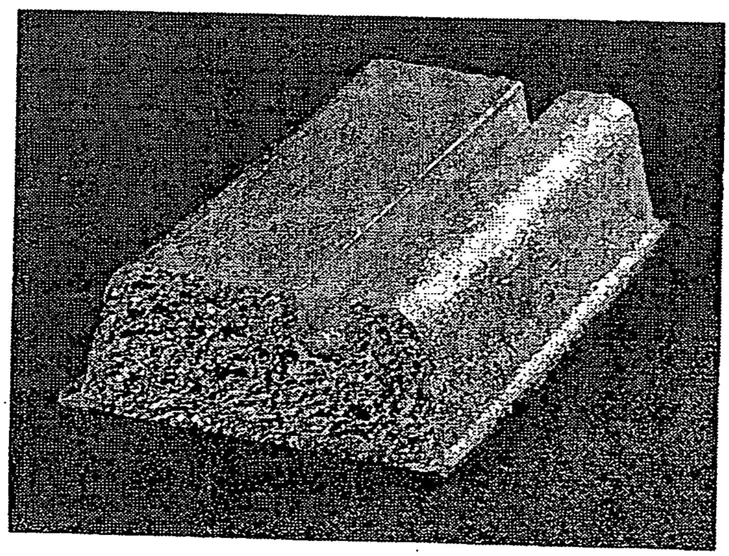


FIG.15

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 93/00471

A. CLASSIFICATION OF SUBJECT MATTER

B 22 D 27/00,C 22 C 1/08,B 22 D 25/06,B 22 D 19/00,
B 22 D 21/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B 22 D 25/00,B 22 D 19/00,C 22 C 1/00,B 22 D 27/00,
B 22 D 21/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO, A1, 91/03 578 (ALCAN INTERNATIONAL) 21 March 1991 (21.03.91), the whole document. --	1,2,3, 5,8, 10,11
A	WO, A1, 91/16 159 (ALCAN INTERNATIONAL) 31 October 1991 (31.10.91), claims 1,2,6-8. --	1,5,10
A	WO, A1, 86/03 997 (GKN TECHNOLOGY) 17 July 1986 (17.07.86), claims 1-6. --	1-14
A	US, A, 3 873 392 (NIEBYLSKI) 25 March 1975 (25.03.75), fig; abstract	1

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January 1994	10. 02. 94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	RIEDER e.h.

INTERNATIONAL SEARCH REPORT

International Application No PCT/CA 93/00471

-2-

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	(cited in the application). --	
A	US, A, 3 847 591 (NIEBYLSKI) 12 November 1974 (12.11.74), claim. ----	1

ANHANG	ANNEX	ANNEXE
a internationalen Recherchen-richt über die internationale tentanmeldung Nr.	to the International Search Report to the International Patent Application No.	au rapport de recherche international relatif à la demande de brevet international n°

PCT/CA 93/00471 SAE 81333

diesem Anhang sind die Mitglieder r Patentfamilien der im obengennten internationalen Recherchenbericht ngeführten Patentdokumente angegeben. ese Angaben dienen nur zur Unterchtung und erfolgen ohne Gewähr.	This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.	La présente annexe indique les membres de la famille de brevets relatifs aux documents de brevets cités dans le rapport de recherche international visée ci-dessus. Les reseignements fournis sont donnés à titre indicatif et n'engagent pas la responsibilité de l'Office.

Im Recherchenbericht geführtes Patentdokument Patent document cited in search report Document de brevet cité ns le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
O A1 9103578	21-03-91	US A 5112697	12-05-92
		AU A1 62876/90	08-04-91
		AU A1 83267/91	17-03-92
		BR A 9007633	07-07-92
		CA AA 2066421	07-03-91
		EP A1 490918	24-06-92
		EP A1 545957	16-06-93
		JP T2 5500391	28-01-93
		JP T2 6500359	13-01-94
		MX A1 9100828	01-04-92
		NO A0 920869	05-03-92
		NO A 920869	05-05-92
		WO A1 9203582	05-03-92
		ZA A 9106664	28-04-93
		US A 5221324	22-06-93
		US A 4973358	27-11-90
		ZA A 9007015	30-10-91
		CA AA 2046814	12-01-93
O A1 9116159	31-10-91	AT E 97039	15-11-93
		AU A1 76672/91	11-11-91
		CA AA 2080377	13-10-91
		CS A2 9101038	12-11-91
		DE A1 4011948	17-10-91
		DE C0 69100631	16-12-93
		EP A1 524233	27-01-93
		EP B1 524233	10-11-93
		ES T3 2046052	16-01-94
		PT A 97345	30-07-93
		TR A 25639	01-07-93
O A1 8603997	17-07-86	AU A1 53081/86	29-07-86
		EP A1 208727	21-01-87
		ES A1 550792	01-12-86
		ES A5 550792	31-12-86
		ES A1 8701554	01-03-87
S A 3873392	25-03-75	US A 3617364	02-11-71
		US A 3839080	01-10-74
		US A 3707401	26-12-72
S A 3847591	12-11-74	US A 3790365	05-02-74